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III.—*Notice of a few Observations which it is desirable to make on the Frozen Soil of British North America; drawn up for distribution among the Officers of the Hudson's Bay Company.* Communicated by Dr. RICHARDSON, F.R.S., Physician to the Royal Hospital at Haslar.

TRAVELLERS into the arctic regions of Asia and America have mentioned that the sub-soil of certain districts is permanently frozen, and Gmelin long ago declared that, in Siberia, the thickness of the frozen earth was upwards of 100 feet; but these statements were either overlooked or disbelieved until very recently, when Professor Baer of St. Petersburg, and Mr. Erman of Berlin, transmitted to the Geographical Society of London some account of the sinking of a well at Yakutsk to the depth of 382 feet in the frozen ground. The temperature was found to increase gradually with the descent of the pit, and at the bottom it had risen from 18° Fahrenheit (−7.8 Cent.), which is the mean annual heat of the place, up to the freezing point; and the soil, which in the upper beds was solidly frozen, had become so loose, that the shaft could not be carried lower without timbering. These facts, when made known to the scientific world, excited great attention, particularly when viewed in connexion with certain opinions entertained respecting the heat of the interior of the globe, and in relation to numerous observations made in the mines of Europe, whence an average augmentation of one degree of temperature of Fahrenheit's scale, for every 45 feet of depth, has been deduced: this rate of increase is about one-third slower than that at Yakutsk.

The inquiry is to be prosecuted still further in Siberia, and Professor Baer suggests that it would be desirable to collect information from the officers of the Hudson's Bay Company, as to the extent of the layer of frozen ground in North America, the thickness it attains in different parallels of latitude, and how much of it disappears towards the latter end of summer; and the council of the Geographical Society, desirous of promoting so important an inquiry in the department of Physical Geography, have requested the following instructions to be drawn up, and, with permission of Governor Pelly, to be circulated, for the guidance of the Chief Factors, Chief Traders, and Clerks of the Hudson's Bay Company, who may be desirous of contributing to the advancement of science by their observations.

As it is not likely that occasions for sinking deep pits or wells in the Hudson's Bay countries will speedily occur, the thickness of the frozen crust cannot be ascertained in the same direct manner as at Yakutsk, but the depth to which the summer thaw penetrates may be noted without much trouble. Sir John Franklin mentions that, at York Factory, in lat. 57°, this did not exceed 3 feet; and on the shores of Great Bear Lake it was only 22 inches. The best time for observing to what depth the soil has been thawed by the summer heat is in "the fall," or the commencement of winter, when the surface begins to freeze again and the snow to lie, that is, early in October, about the 56th parallel, and in the month of September farther north. Every locality where frozen sub-soil is discovered by digging in the summer should be mentioned, so that, when observations are sufficiently multiplied, the southern boundary of the frozen stratum may be traced on the map. And if spots be found in the higher latitudes without any such frozen bed, the peculiarities of its situation should be recorded, particularly those which render its drainage more perfect, or contribute to elevate its summer temperature, such as the presence of decomposing beds of bituminous shale, producing pseudo-volcanoes, the vicinity of thermal springs, or the reflection of the sun's rays from lofty walls of rock. [The very high summer heat of some narrow valleys in the north of Sweden has been attributed to the latter cause.] The nature of the soil, whether clayey or sandy, retentive of water or porous, should also be noted. Sandstones, apparently hard and compact, dug up on the banks of Mackenzie's river, were found to thaw and crumble into moist sand when laid before a fire. If time admits of it, several openings may be made in the same neighbourhood, and the mean depth of thawed soil obtained, or the results may be recorded in a tabular form.

It is scarcely necessary to remark that, for the attainment of the object in view, it is desirable to have as many facts as possible, and that the names of places where the soil thaws perfectly every summer should be as carefully transmitted as those where the thaw penetrates only a few inches. Many facilities for observation will occur when gentlemen are travelling from their winter-quarters to the depôts, and if the latitude of the place be not exactly known, its distance from some post marked in Arrowsmith's map may be mentioned. As these journeys or voyages are made on the larger rivers, whose banks are liable to be inundated by spring floods, and to be covered by water for some time, when observations are taken in such places a memorandum to that effect should be made.

There are several reasons for supposing that, in the interior of the Hudson's Bay territories the climate is nearly the same as that of Siberia, and we know that on the northern shores of Great Slave Lake, in lat. 62°, which is the parallel upon which Yakutsk stands, the mean annual heat is very nearly the same as at the latter place. In that neighbourhood, therefore, we may expect to find the frozen soil as thick as at Yakutsk; at Fort Chipewyan, where the mean temperature is supposed to be between 29 and 30 degrees, the depth of frozen soil, by the same rule, will not exceed 60 feet; and, towards Cumberland-house, where the average heat of the year is rather above the freezing point, the frozen sub-stratum will probably be found to feather off to nothing. Facts, in proof or contradiction of these suppositions, are required; and between Athabasca and the Saskatchewan, the frozen stratum being very thin, may be entirely penetrated with little labour, particularly at the posts of Isle à la Crosse or Lac la Ronge, or, perhaps still better, on the Peace River and its southern branches. Even in the higher latitudes, as on the Mackenzie, much information may be gained by visiting some of the recent land-slips which occur annually on the banks of the larger rivers. In such a case the height of the top of the bank from the water, the width of the slip, and the age of the crevice, whether newly formed, or the work of a preceding season, should be recorded. Cliffs, several hundred feet high, composed of crumbling rocks, washed at the base by the Mackenzie and Bear Lake rivers, are noticed in Sir John Franklin's journal. Should one of these happen to give way to the thickness of 400 feet, both vertically and horizontally, an inspection of the walls of the crevice would reveal the depth of the frozen earth as effectually as the well does at Yakutsk. Land-slips of less magnitude are more likely to take place, and are not to be neglected.

Another very interesting mode of ascertaining the depth of frozen soil in different parallels offers itself. Professor Baer quotes an incident which happened to Baron Wrangell while riding to the north of Yakutsk, in lat. 65°, over a large river; the ice suddenly giving way, he was thrown forwards and escaped, but his horse went under. He was lamenting the loss of his steed, when the Yakutskis, laughing, told him that the horse was not only safe but dry; and, eventually, when the ice was broken away, it was discovered that there was no water beneath, and that the animal was standing upon the perfectly dry bed of the river. Similar streams, fed only by superficial springs, and consequently ceasing to flow in winter, must be known to the gentlemen of the Hudson's Bay Company; but there are many large and rapid rivers also known to them, which continue during the whole winter to pour large volumes of water into the Arctic Sea. The Mackenzie itself is mostly supplied from districts having a mean heat inferior to the freezing point: its more southerly branches being comparatively small. Now, the waters which sustain the perennial course of many of the tributaries of the Mackenzie, the Great Bear Lake River, for instance, must rise from beneath the frozen stratum. Dease's River, and all the other feeding streams of Great Bear Lake, taken in the aggregate, yield, even in the summer, a much smaller quantity of water than that which is discharged by Bear Lake River; and there is no remarkable lowering of the surface of the lake in the winter, though the stream that issues from it is too rapid to freeze, is 300 yards wide, and several fathoms deep; hence the great supply must come from the bottom of the lake itself. The depth of one of the arms of the lake has been ascertained to be about 240 feet; but, as the average heat of the year there does not exceed 14 or 17 degrees of Fahrenheit, the source of the perennial springs cannot be estimated at less than 400 feet. The ascertaining of the greatest depth of this lake may therefore be useful in guiding us to a right conclusion, and this may be still more readily accomplished by sounding smaller lakes, which give origin to streams that flow all the winter. Sir John Franklin saw many such lakes in the course of his journey, and, in most instances, there was a rapid at the point where the stream broke off from the lake. The uppermost, in a string of lakes, particularly if its feeding streams are frozen up in winter, is obviously the best for examination, Dease's River, before mentioned, flows through two small lakes, which are very likely to afford useful information, if properly sounded; and, as the intelligent and active gentleman whose name the river bears, wintered at its mouth in 1837, and perhaps will do so also in the present season, we are not without hope of learning much from his observations, though, unfortunately, he is not aware of the interest excited by Professor Baer's statement.

Notices of perennial springs, and of the rocks from whence they issue, whether lime-stone, sand-stone, or shale, are highly desirable. Several occur in the Athabasca River, where they are readily detected in winter by remaining unfrozen, or covered only by a thin crust of ice, on which account they are noted by the voyagers as halting places on their winter journeys. There is a remarkable one issuing from lime-stone, covered by a bed of shale, at the junction of Clearwater River with the Athabasca. The temperature of this spring should be ascertained, and, also, that of any other copious fountain, such as the salt springs on the Slave River, which pour out very large volumes of water.

This paper has been drawn up with a knowledge of the limited means possessed by the officers of the Hudson's Bay Company for making researches of this kind, and of the important and laborious avocations which employ their time; but much is hoped for from their zeal and intelligence. The only instruments required for ascertaining the depth of the summer thaw are a spade and a foot rule; and letters, detailing the facts ascertained, may be addressed to the Secretary of the Royal Geographical Society, 21, Regent-street, London.

[A Paper, with similar objects in view, drawn up at the suggestion of M. Arago, having been circulated by the Governor and Committee in 1835, the results of any inquiries made in consequence thereof may also be transmitted to the Secretary of the Geographical Society.]